FIREChem

Fire Impacts on Regional to Global Scales: Emissions, Chemistry, Transport, and Models

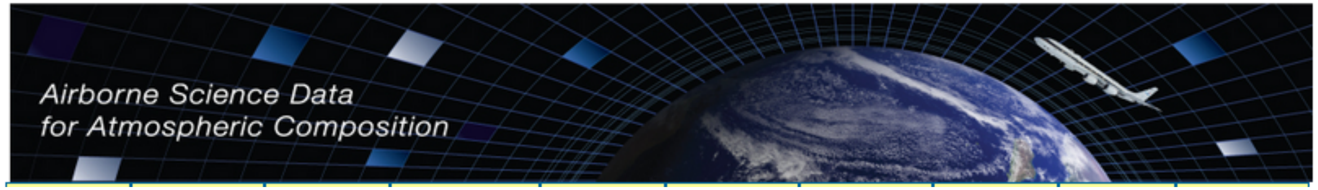
Amber Soja, amber.j.soja@nasa.gov

Primary NASA Contacts:

Barry Lefer, NASA HQ, barry.lefer@nasa.gov

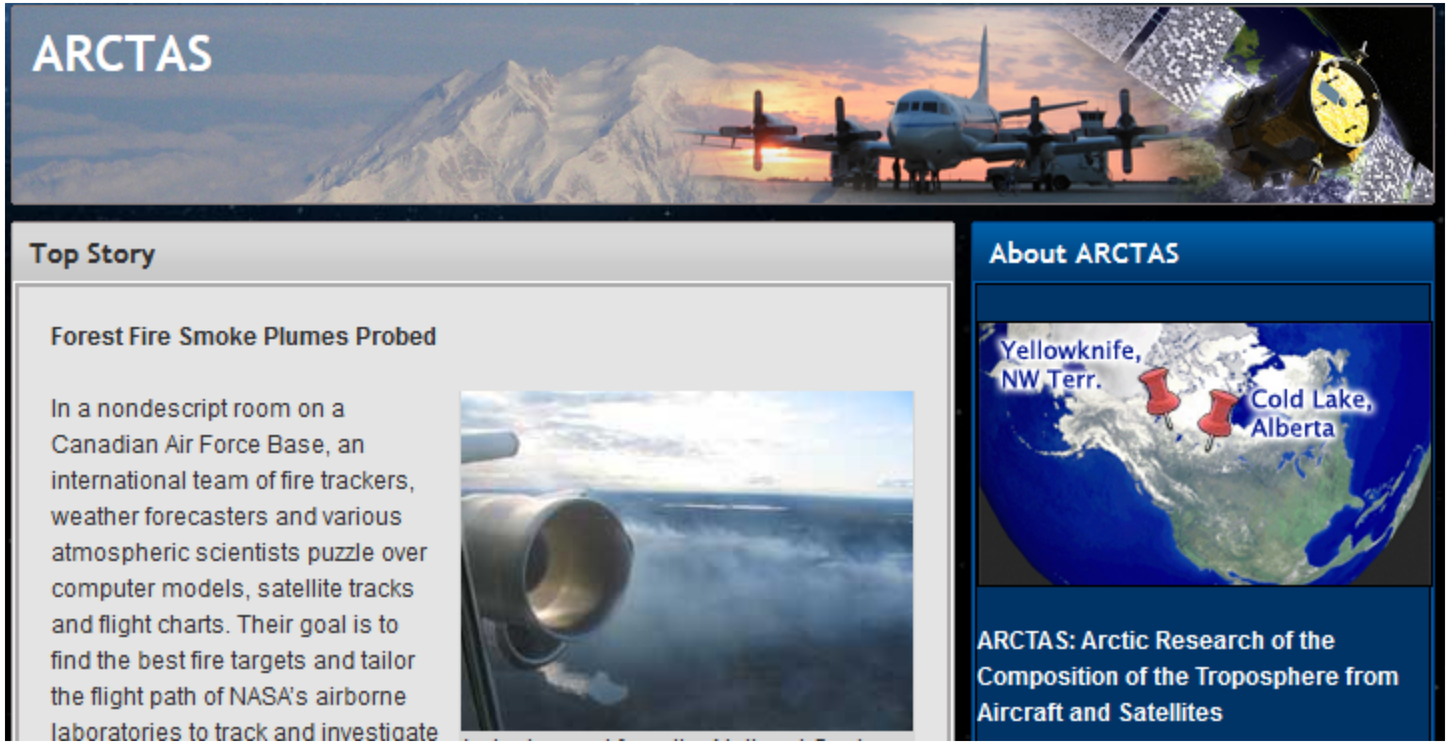
Jim Crawford, NASA Langley, james.h.crawford@nasa.gov

The ***Tropospheric Composition Program*** **(TCP)** seeks to improve the utility of satellite measurements in understanding of global tropospheric ozone and aerosols, including their precursors and transformation processes in the atmosphere. Ozone and aerosols are fundamental to both air quality and climate.



NASA Transport and Chemical Evolution over the Pacific (TRACE-P)

INTEX-NA aimed to understand the transport and transformation of gases and aerosols on transcontinental & intercontinental scales and assess their impact on air quality and climate. The primary constituents of interest are ozone and its precursors, aerosols and precursors, and the long-lived greenhouse gases.



Details are tentative:

Dates: 25 July – 15 September 2019

Location: Salina, KS

Research Platform: NASA DC-8

FIREChem Timeline (dates are approximate)

1 February 2017 – White Paper Complete

14 February 2017 – Solicitation for Proposals Released

15 May 2017 – Proposals Due

September 2017 – Proposal Selections Announced

Note: The white paper defines the scientific scope of FIREChem needed to enable science team selection and definition of the scientific payload. Deployment details and sampling strategies, however, remain flexible in response to new information and the realities of conditions encountered during the deployment.

FIREChem Objectives

FIREChem flights will contribute to the planned interagency collaboration in three areas:

1 – Sampling of wildfires in coordination with interagency partners to understand near vs far-field observations, chemical evolution, and transport to evaluate downwind impacts.

Accomplishing this goal requires heavy coordination of flights with NOAA and potentially NSF with input and advice from the Joint Fire Science Program. This goal takes priority when wildfires of sufficient size and regional impact are active.

2 – Sampling of small to medium fires to build statistics on emission factors and fuels, plume rise, satellite detection, and integrated impacts.

Accomplishing this goal requires liaison with state and local authorities to anticipate when and where to expect burning.

3 – Sampling of prescribed burns in coordination with FASMEE

This objective provides the best chance for bridging laboratory and ambient conditions and takes priority when burns are announced.

FIREChem Science Questions

1) What are the emissions of gases, aerosols, aerosol precursors, and greenhouse gases from North American fires? How variable are these emissions due to fuel and fire conditions?

2) How does the composition of fire plumes change as primary species are converted to secondary gas and aerosol tracers?

3) How is local air quality impacted by North American fires? How well do air quality forecast models work when influenced by fire emissions?

4) What are the regional impacts of North American fires?

5) What are the climate-relevant properties of BB aerosols? What role does brown carbon and coatings on black carbon particles play in the optical properties? What is the composition of PM?

6) How can satellite measurements help with #1-5? And how can we obtain better satellite estimates of plume height and fire intensity (e.g., fire radiative power)?

Example: KORUS-AQ DC-8 Measurement Priorities

Gas Phase In Situ	Priority	Detection Limit	Resolution
O3	1	1 ppbv	1 s
H2O	1	10 ppmv	1 s
CO	1	5 ppbv	1 s
CH4	1	10 ppbv	1 s
CO2	1	0.1 ppm	1 s
NMHCs	1	<10%	1 min
NO	1	10 pptv	1 s
NO2	1	20 pptv	1 s
HCH	1O	50 pptv	1 s
OH, HO2, RO2	2	0.01/0.1/0.1 pptv	30 s
OH reactivity	2	1 s^{-1}	10 s
H2O2	2	50 pptv	10 s
ROOH	2	50 pptv	10 s
HNO3	2	50 pptv	10 s
PANs	2	50 pptv	10 s
RONO2	2	50 pptv	10 s
SO2	2	10 pptv	1 s
CH3CN	2	10 pptv	1 min
NOy	3	50 pptv	1 s
Halocarbons	3	variable	1 min
HCN	3	10 pptv	1 min
NH3	3	30 pptv	1 min
N2O	3	1 ppbv	10 s
Organic Acids	3	10 pptv	1 min

Aerosol In Situ	Priority	Detection Limit	Resolution
Size Distribution/Number	1	NA	10 s
Volatility	1	NA	1 s
Scattering	1	1 Mm-1	1 s
Absorption	1	0.2 Mm-1	10 s
Hygroscopicity	1	NA	10 s
Ionic composition	1	50 ng m^{-3}	5 min
Organic composition	1	100 ng m^{-3}	1 min
Black carbon	1	50 ng m^{-3}	1 s
Size-resolved composition	2	100 ng m^{-3}	1 min
Single particle composition	2	<4 µm dia.	5 min
CCN	2	<4 µm dia.	1 s
Cloud particle size dist.	2	0.05-1000 µm	1 s
Radionuclides (^{222}Rn, ^{7}Be, ^{210}Pb)	3	1/100/1 fCi m^{-3}	5 min

Remote Sensing, Radiation, and Met	Priority	Detection Limit	Resolution
UV spectral actinic flux (4π sr)	1	80° SZA equivalent	5 s
Ozone lidar (nadir/zenith)	1	5 ppbv or 10%	300 m
Trace Gas Columns (O_3, NO_2, C_2HO)	1	variable	variable
Multi-spectral optical depth	1	0.01	1 s
Aerosol profiles of extinction	1	10 Mm^{-1} or 10%	300 m
Aerosol profiles of backscatter	1	3%	30 m
Aerosol profiles of depolarization	1	3%	30 m
High Resolution Met (T, P, winds)	2	0.3K, 0.3 mb, 1 ms^{-1}	1 s
Hyperspectral solar flux	3	4%	1 s
Broadband flux	3	5%	1 s

DC-8 Measurement Requirements and Priorities

Gas Phase In Situ	Priority	Detection Limit	Required Resolution	Desired Resolution
O_3	1	1 ppbv	1 s	5 Hz
H_2O*	1	10 ppmv	1 s	5 Hz
CO*	1	5 ppbv	1 s	5 Hz
CH_4*	1	10 ppbv	1 s	5 Hz
C_2H_6	1	50 pptv	1 s	5 Hz
CO_2*	1	0.1 ppm	1 s	5 Hz
NMHCs	1	<10%	1 min (full suite)	5 Hz (selected species)
NO	1	10 pptv	1 s	5 Hz
NO_2	1	20 pptv	1 s	5 Hz
HCHO*	1	50 pptv	1 s	5 Hz
CH_3CN	1	10 pptv	1 s	5 Hz
HCN	2	10 pptv	1 s	-
NH_3	2	30 pptv	1 s	-
HONO	2	50 pptv	1 s	-
Organic Acids	2	10 pptv	10 s	1 s
H_2O_2	2	50 pptv	10 s	1 s
ROOH	2	50 pptv	10 s	1 s
NOy	2	50 pptv	1 s	5 Hz
HNO_3	2	50 pptv	10 s	1 s
PANs	2	50 pptv	10 s	1 s
$RONO_2$	2	50 pptv	10 s	1 s
SO_2	2	10 pptv	1 s	-
OH reactivity	2	1 s^{-1}	10 s	1 s
OH, HO_2, RO_2	2	0.01/0.1/0.1 pptv	30 s	1 s
Halocarbons	3	Variable	1 min	-
N_2O*	3	1 ppbv	1 s	-

Aerosol In Situ	Priority	Detection Limit	Required Resolution	Desired Res.
Particle Number*	1	NA	1 s	5 Hz
Size Distribution (10 nm-5 µm)*	1	NA	10 s	1 s
Volatility*	1	NA	1 s	5 Hz
Scattering*	1	1 Mm^{-1}	1 s	-
Scattering Phase Function	1	3 Mm^{-1}	5 s	-
Hygroscopicity*	1	NA	10 s	1 s
Absorption*	1	0.2 Mm^{-1}	10 s	-
Brown Carbon Absorption	1	1 Mm^{-1}	per plume	30 s
Size-resolved Composition	1	100 ng m^{-3}	1 s	-
Organic mass	1	100 ng m^{-3}	10 s	1 s
Black Carbon	1	50 ng m^{-3}	1 s	5 Hz
Bulk Composition	2	50 ng m^{-3}	per plume	-
Single particle Composition	2	<4 µm dia.	1 s	-
CCN/IN	2	<4 µm dia.	1 s	-
Cloud particle size dist.*	2	0.05-1000 µm	1 s	-

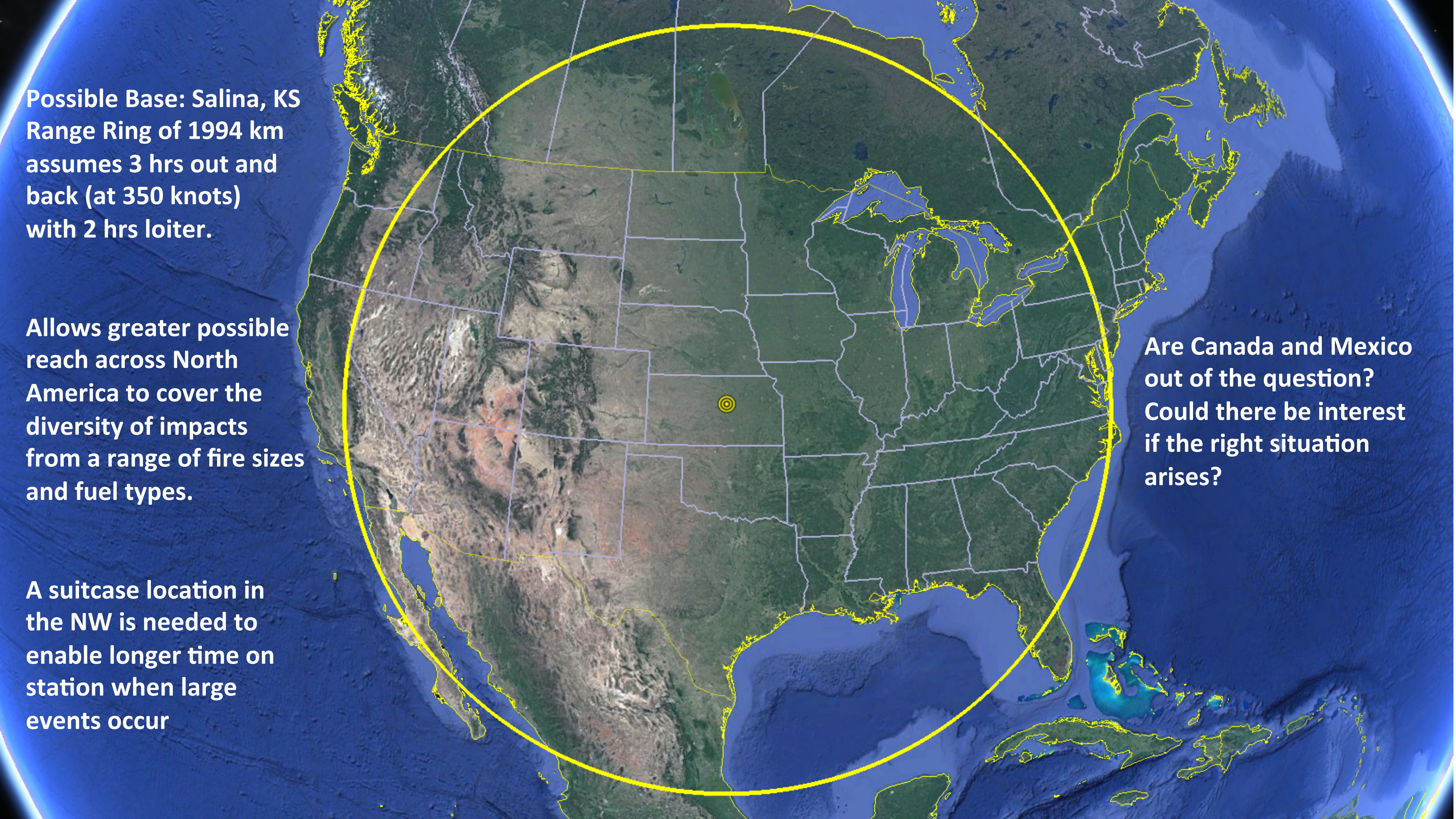
***Denotes measurements to be provided by NASA facility instruments**

DC-8 Measurement Requirements and Priorities

Remote Sensing, Radiation, and Met	Priority	Detection Limit	Required Resolution
Aerosol profiles of extinction*	1	10 Mm^{-1} or 10%	300 m
Aerosol profiles of backscatter*	1	3%	30 m
Aerosol profiles of depolarization*	1	3%	30 m
High Resolution Met (T, P, winds)*	1	0.3K, 0.3 mb, 1 ms^{-1}	10 Hz
UV spectral actinic flux (4π sr)	1	80° SZA equivalent	1 s
Surface IR Imaging (FRP)*	2	-	-
Ozone lidar (nadir/zenith)*	2	5 ppbv or 10%	300 m
Trace Gas Columns (O_3,NO_2,CH_2O)*	2	Variable	Variable
Multi-spectral Optical Depth*	3	0.01	1 s

IR imaging?

***Denotes measurements to be provided by NASA facility instruments**

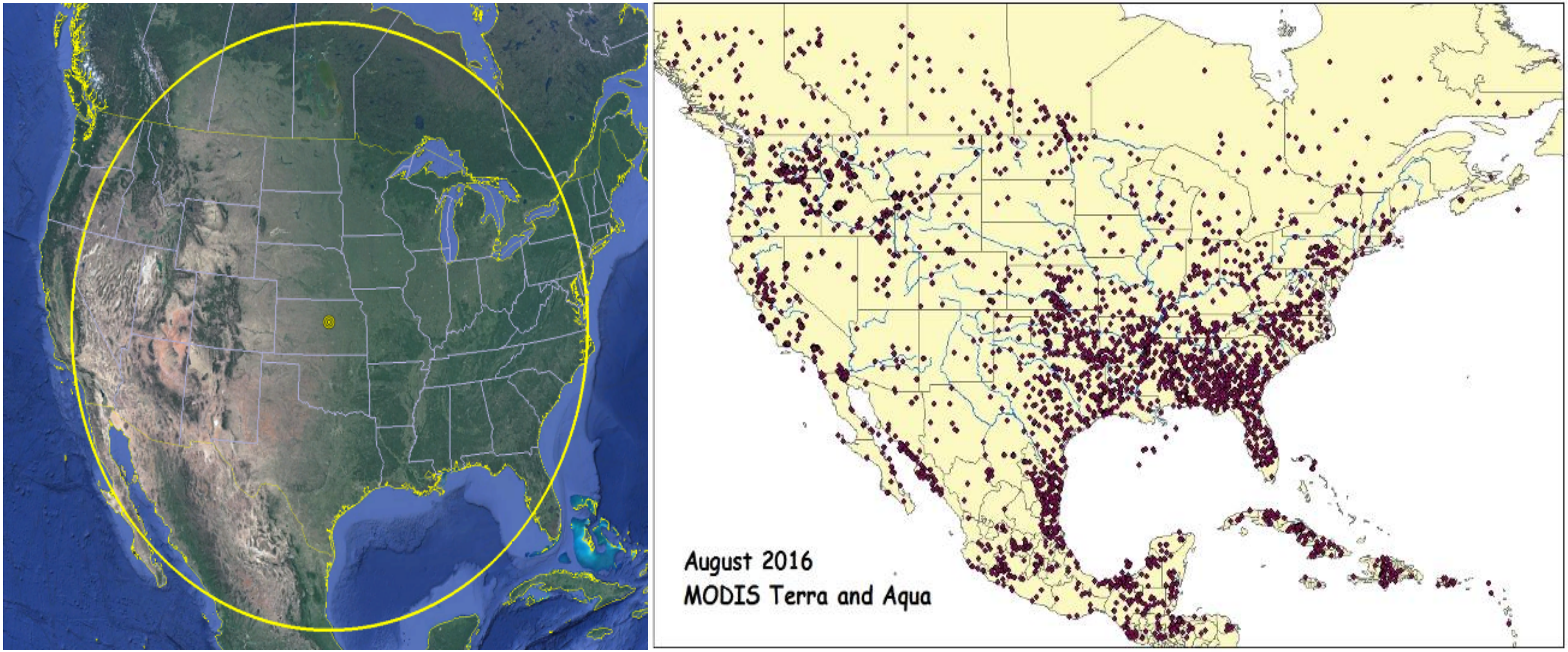


Possible Base: Salina, KS
Range Ring of 1994 km assumes 3 hrs out and back (at 350 knots) with 2 hrs loiter.

Allows greater possible reach across North America to cover the diversity of impacts from a range of fire sizes and fuel types.

A suitcase location in the NW is needed to enable longer time on station when large events occur

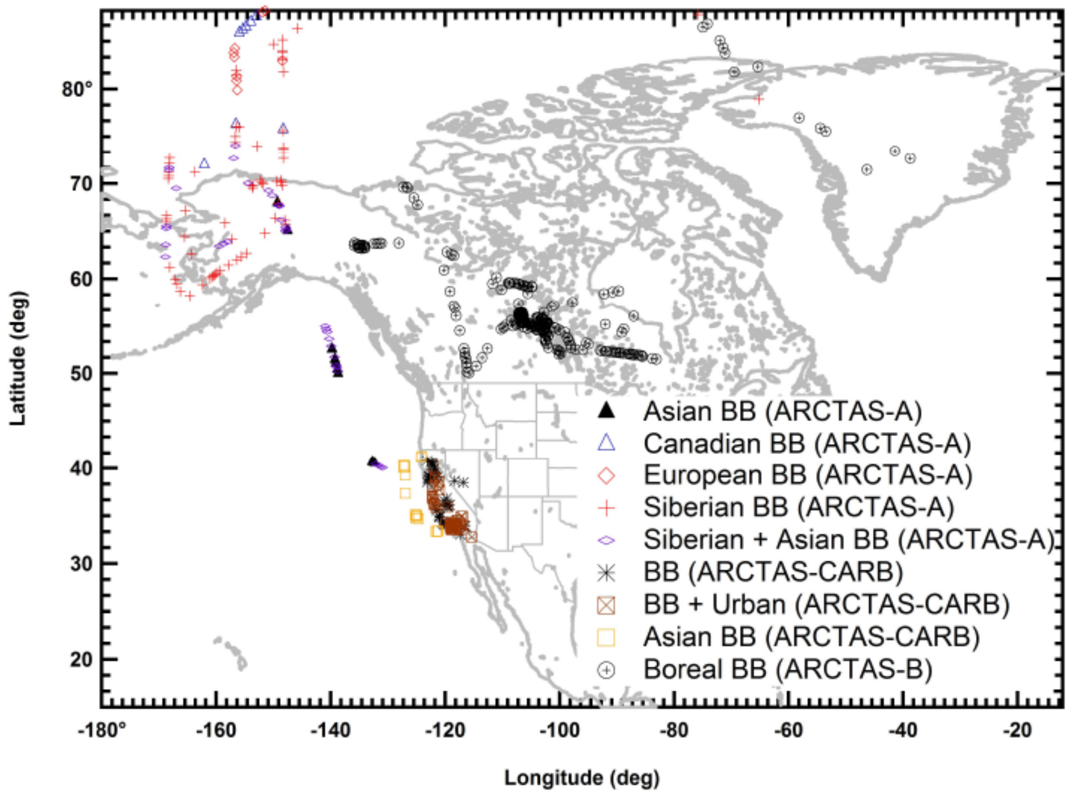
Are Canada and Mexico out of the question? Could there be interest if the right situation arises?



Left Panel: DC-8 sampling range from Salina, KS based on a 3 hour transit time to the edge of the yellow range ring, thus enabling a minimum of 2 hours loiter time in an 8 hour flight. Right Panel – Distribution of fire counts detected by MODIS in August 2016. Locations vary from year-to-year, but activity in consistently weighted to the northwest and southeast U.S.

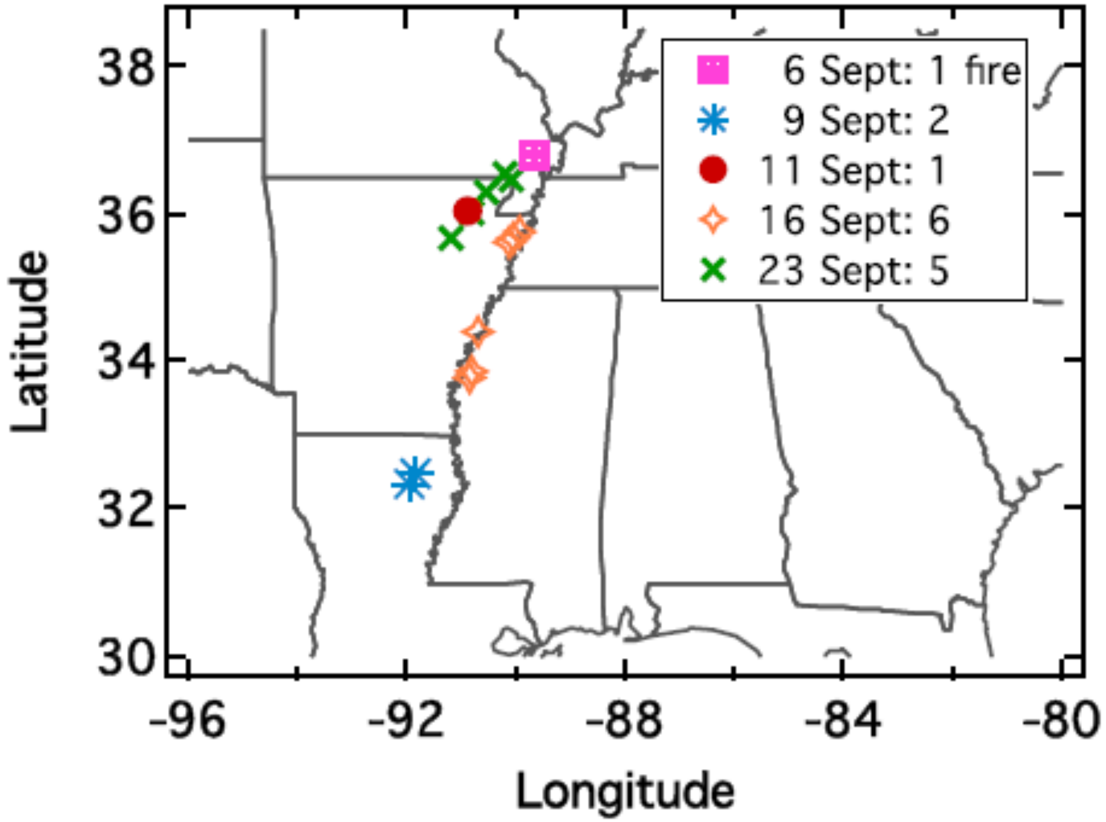
FIREChem challenges us to sample differently.

Hecobian et al., ACP, 2011



495 detections of fire influence

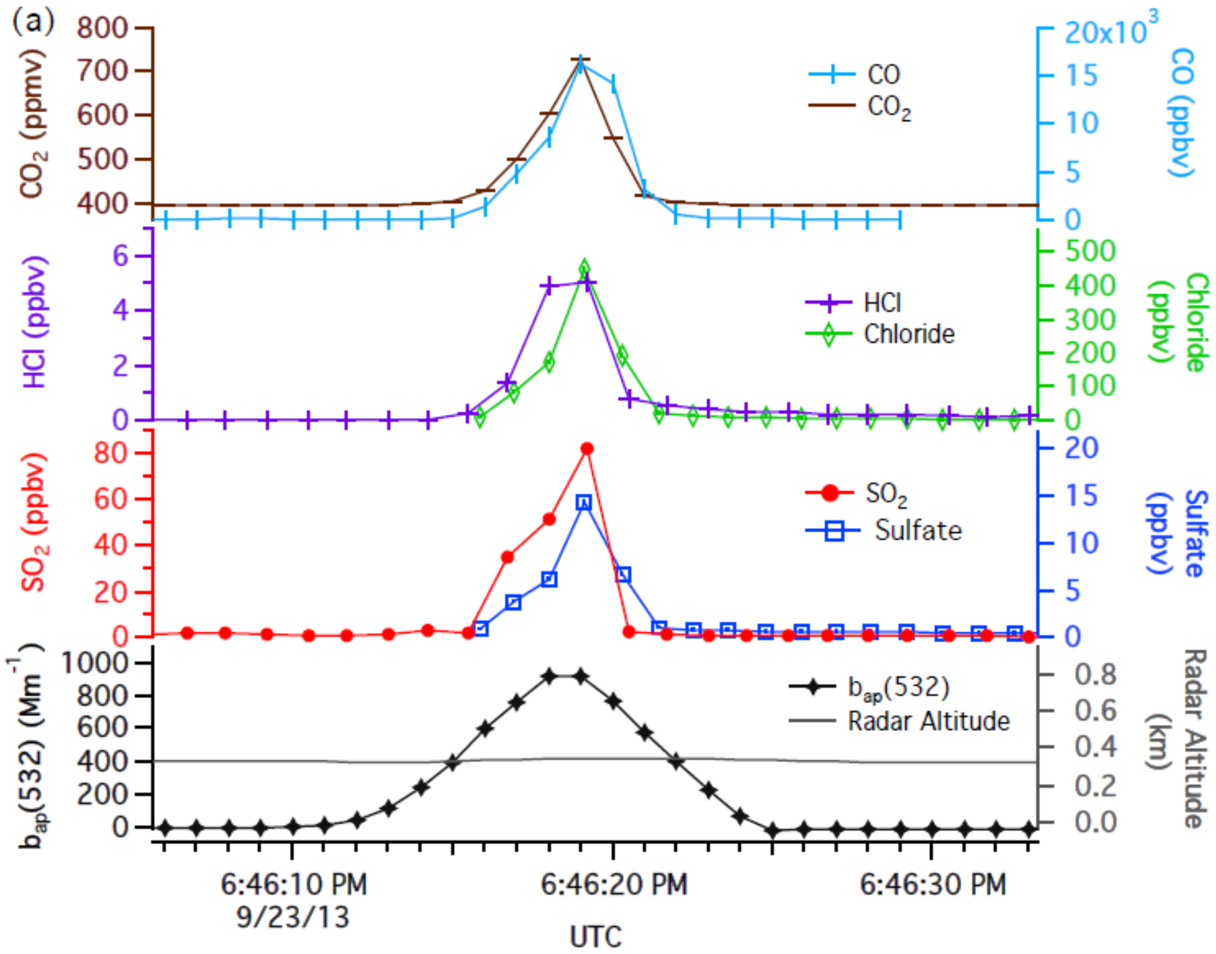
Liu et al., JGR, 2011



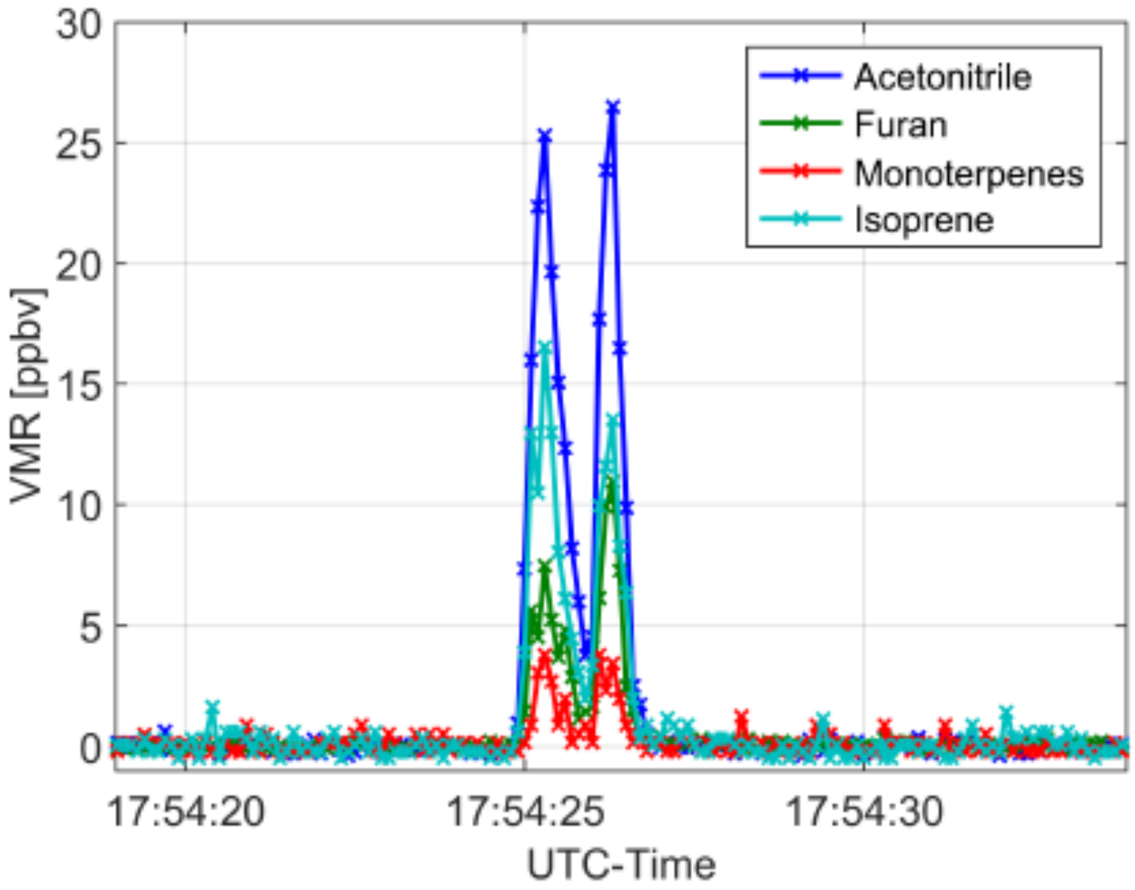
15 targeted samples of small fire emissions

FIREChem challenges us to sample differently.

Liu et al., JGR, 2011



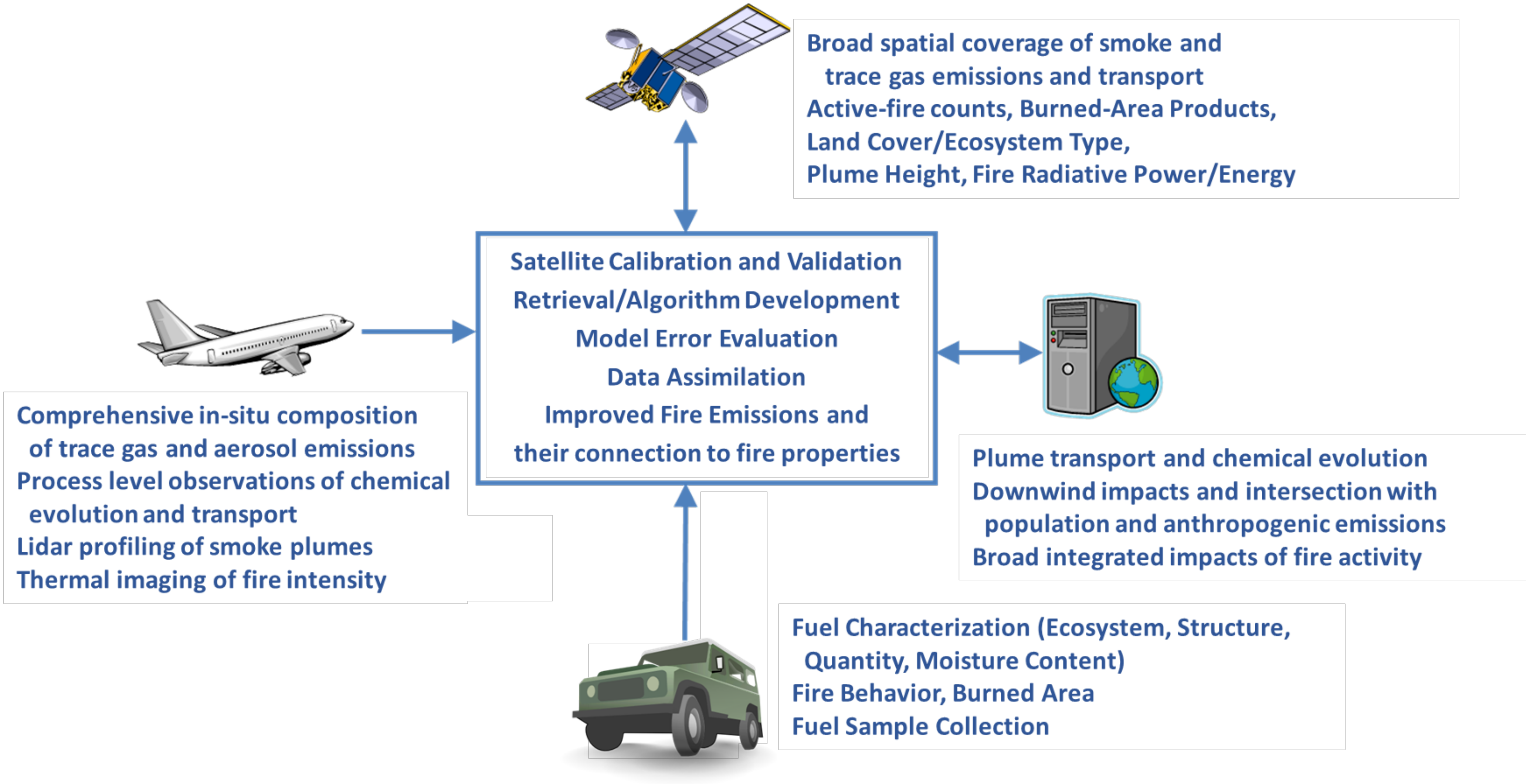
Muller et al., ACP, 2016



1 Hz sampling of small fire over 5 seconds

10 hz sampling of small fire over 2 seconds

FIREChem seeks to inform integrated observing strategies.



FIREChem: working with out partners

1) **Help with airspace coordination (active control), especially for fires under active control. Obtaining permission, developing a plan for aircraft separation, etc.**

2) **Connection to ground conditions. Gathering information on what was burning, fuel loading, duration, etc.**

3) **Prediction of small fire activity. Are there organized plans for burning? When are fires expected to start? Where are conditions conducive to burning? Can GOES provide guidance or updates on burning progress?**

4) **Advice on selection of fires to target. Which fire is likely to yield more information. Is it in an area that is well characterized? Is it likely to persist?**

A.23	Fire Impacts on Regional to Global Scales: Emissions, Chemistry, Transport, and Models	NOI / Step 1 N/A	Proposal Due Date 05/19/2017

https://espo.nasa.gov/FIREChem_White_Paper